



Application of ET Remote Sensing for the National Water Census

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National Water Census

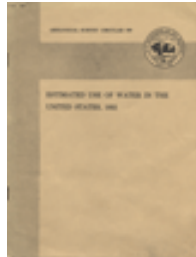
- USGS research program on *water availability* and *water use*, developing and applying new water accounting tools
- From 2011, implemented using the unifying concept of a *national water budget*
- A consistent description of water budget components nationally and regionally
- For assessment of status and trends of water availability and use in the U.S.



Estimated Use of Water in the United States



1950



1955



1960



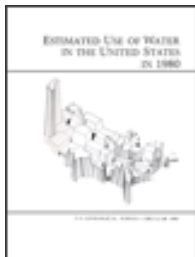
1965



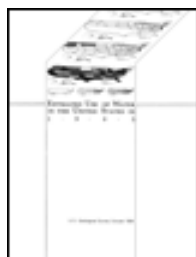
1970



1975



1980



1985



1990



1995



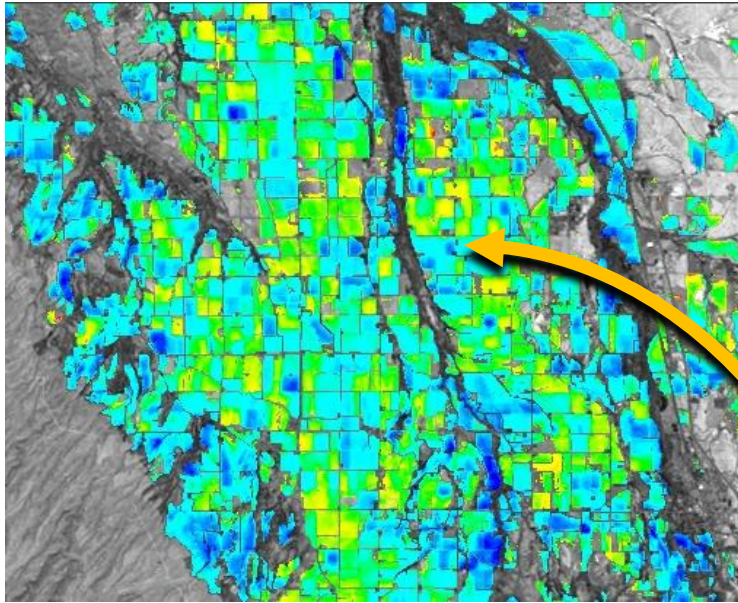
2000



2005



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D. Eckhardt, USBR

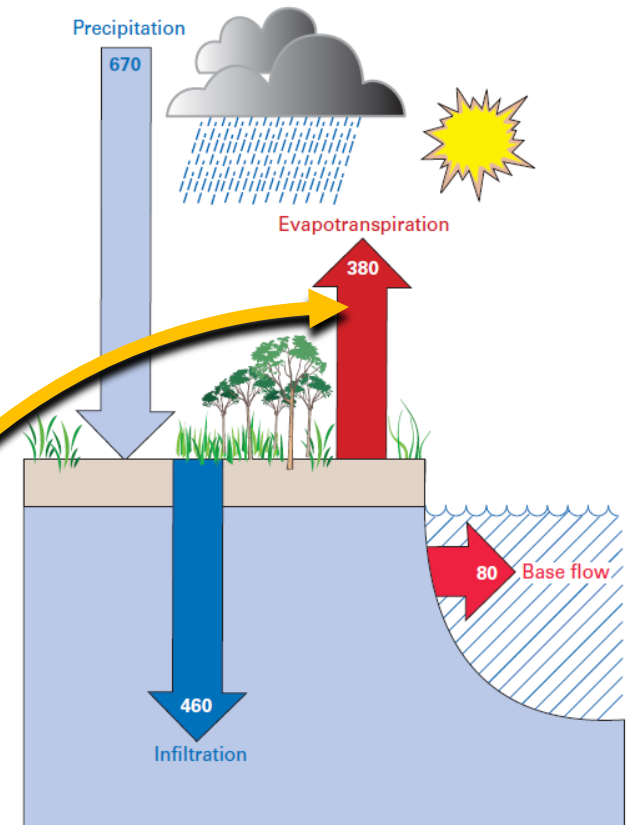
ET

Water Use Evaluations:

Consumptive use by
irrigated crops
Crop water productivity



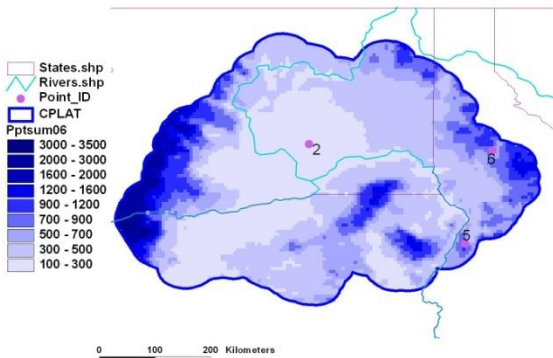
12 digit HUC Watershed



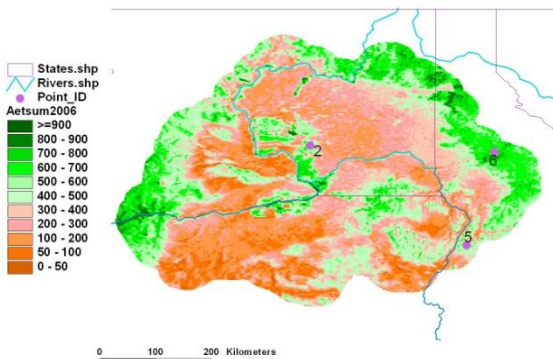
Water Availability:
Landscape ET as a
component of the overall
water budget

Columbia Plateau Regional Aquifer Study

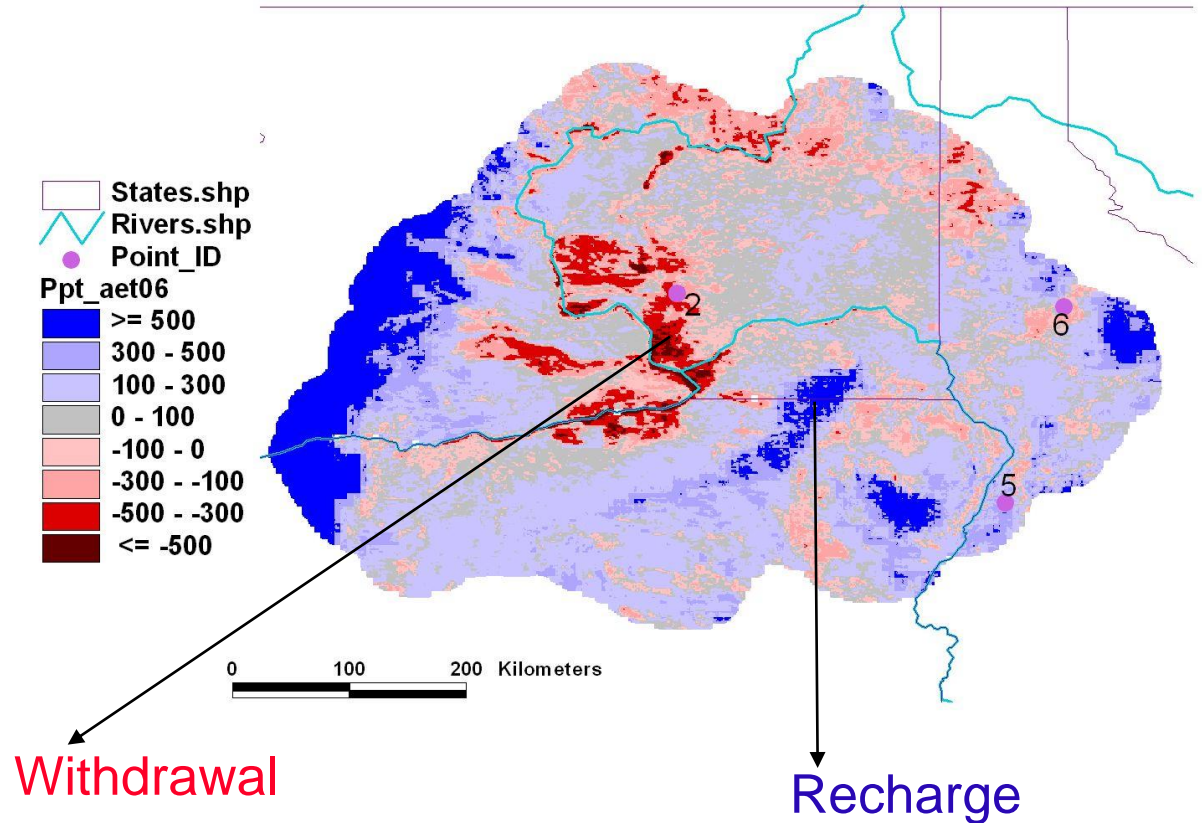
2006 Annual Precipitation (mm)
(NOAA/NEXRAD)



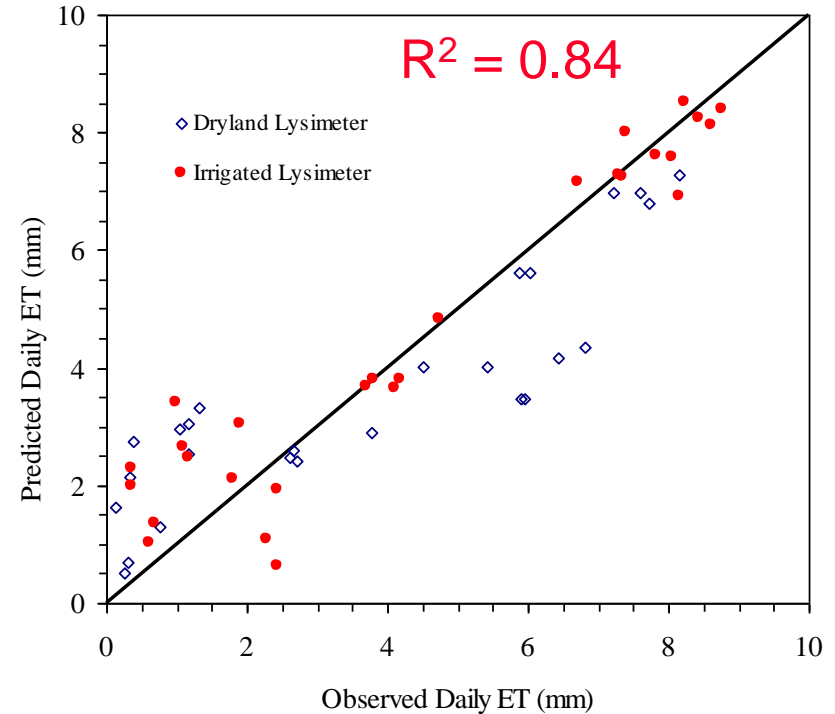
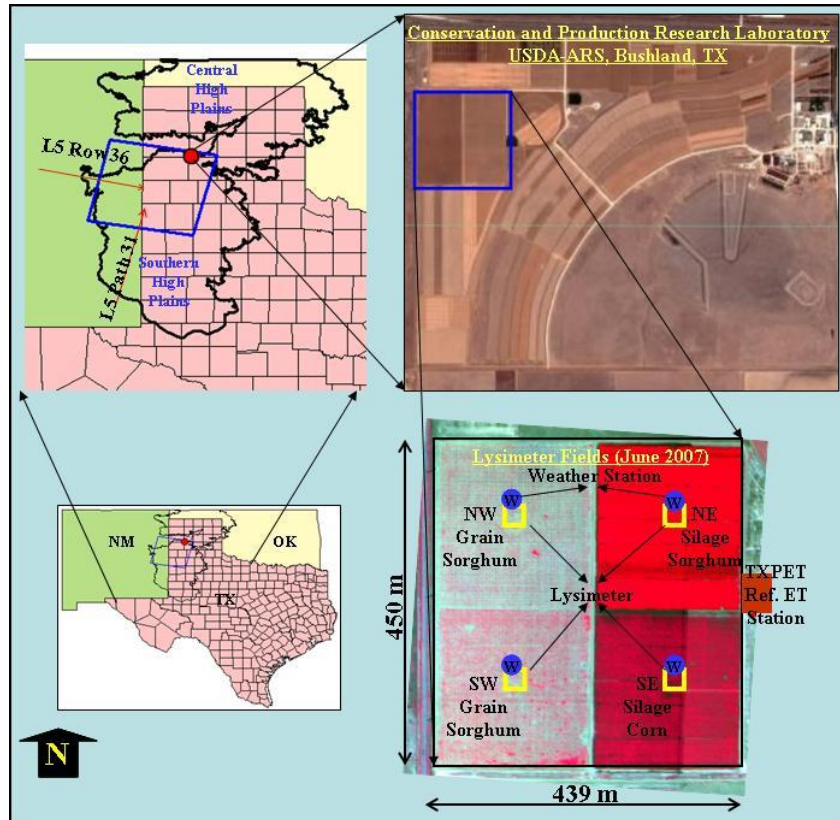
2006 Annual ETa (mm)
Columbia Plateau: SSEB, Jan - Dec



2006 Annual Water Balance (PPT - ETa) (mm)
Columbia Plateau: NOAA/NEXRAD Precip minus SSEB ETa)



Simplified Surface Energy Balance (SSEB) Validation against Lysimeter ET Data



SSEB ETa versus observed daily ET on four large Lysimeters in Bushland, Texas.
Thermal Data: Landsat TM; 14 images; March – August, 2006/2007.
(Gowda et al., 2009, ASABE)

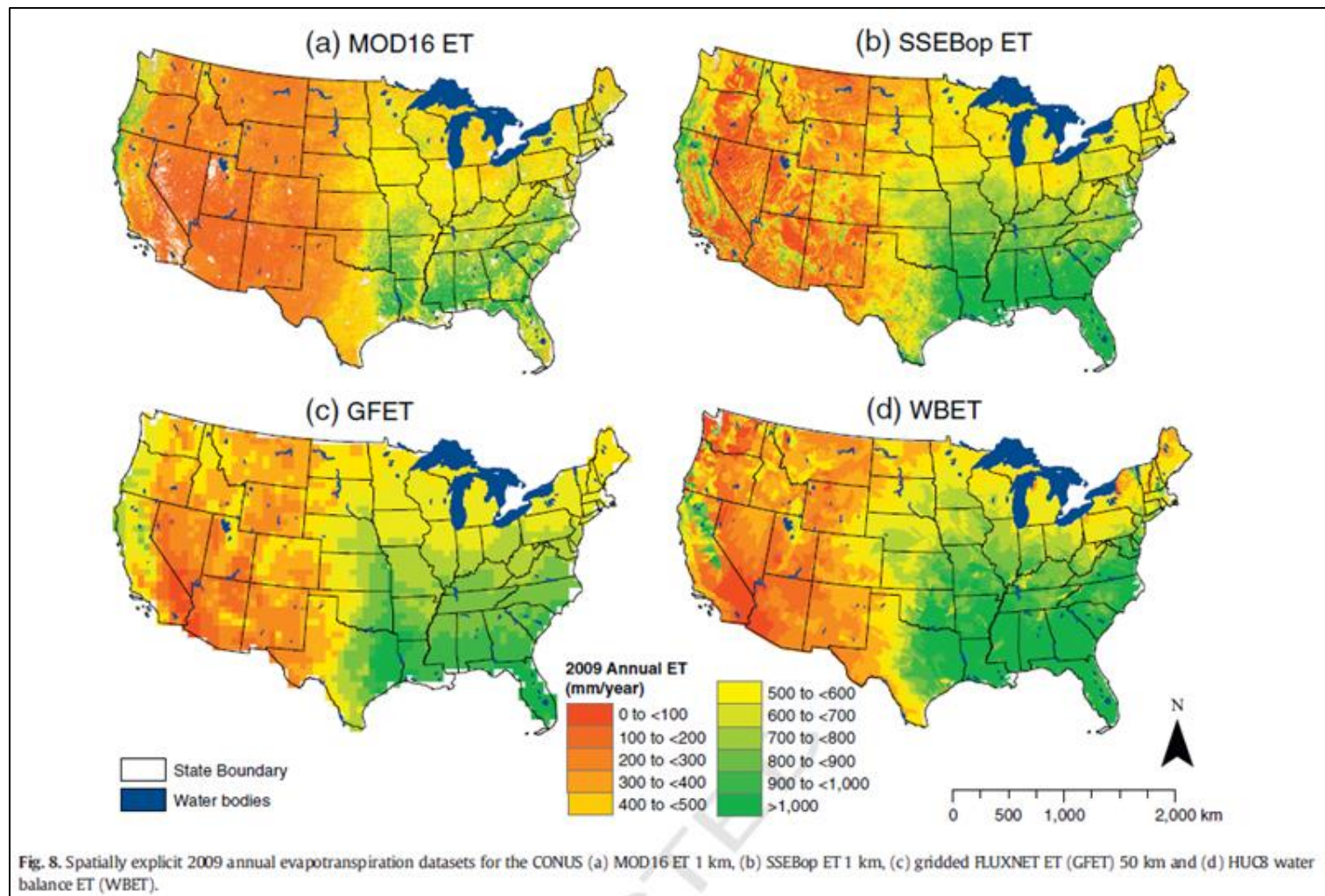


Fig. 8. Spatially explicit 2009 annual evapotranspiration datasets for the CONUS (a) MOD16 ET 1 km, (b) SSEBop ET 1 km, (c) gridded FLUXNET ET (GFET) 50 km and (d) HUC8 water balance ET (WBET).

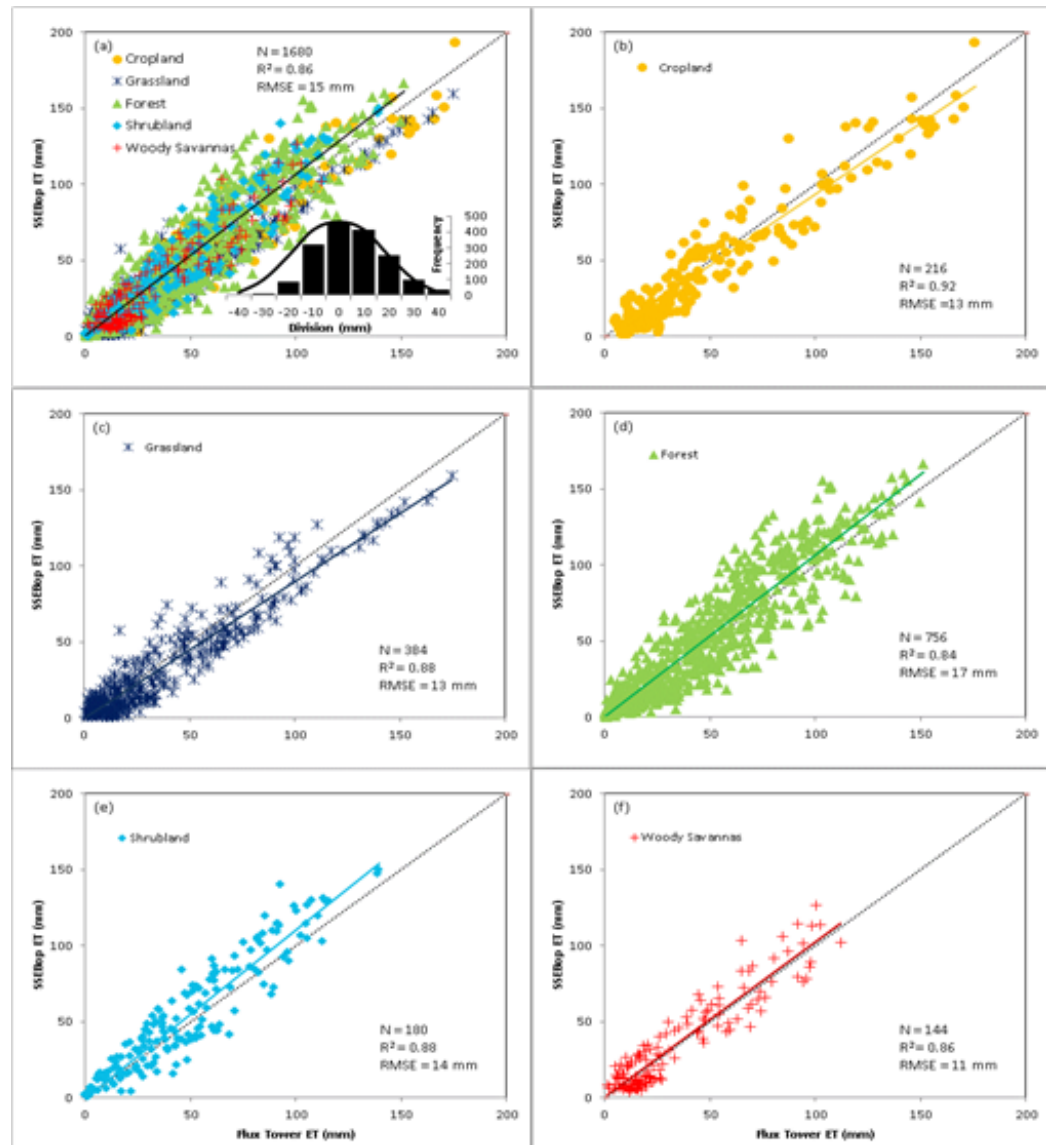
SSEBop MODIS ETa validated w.r.t:

NASA MOD16 ET; Max Planck Institute Gridded ET Flux; HUC 8 Basin Water Balance ($P-Q$)

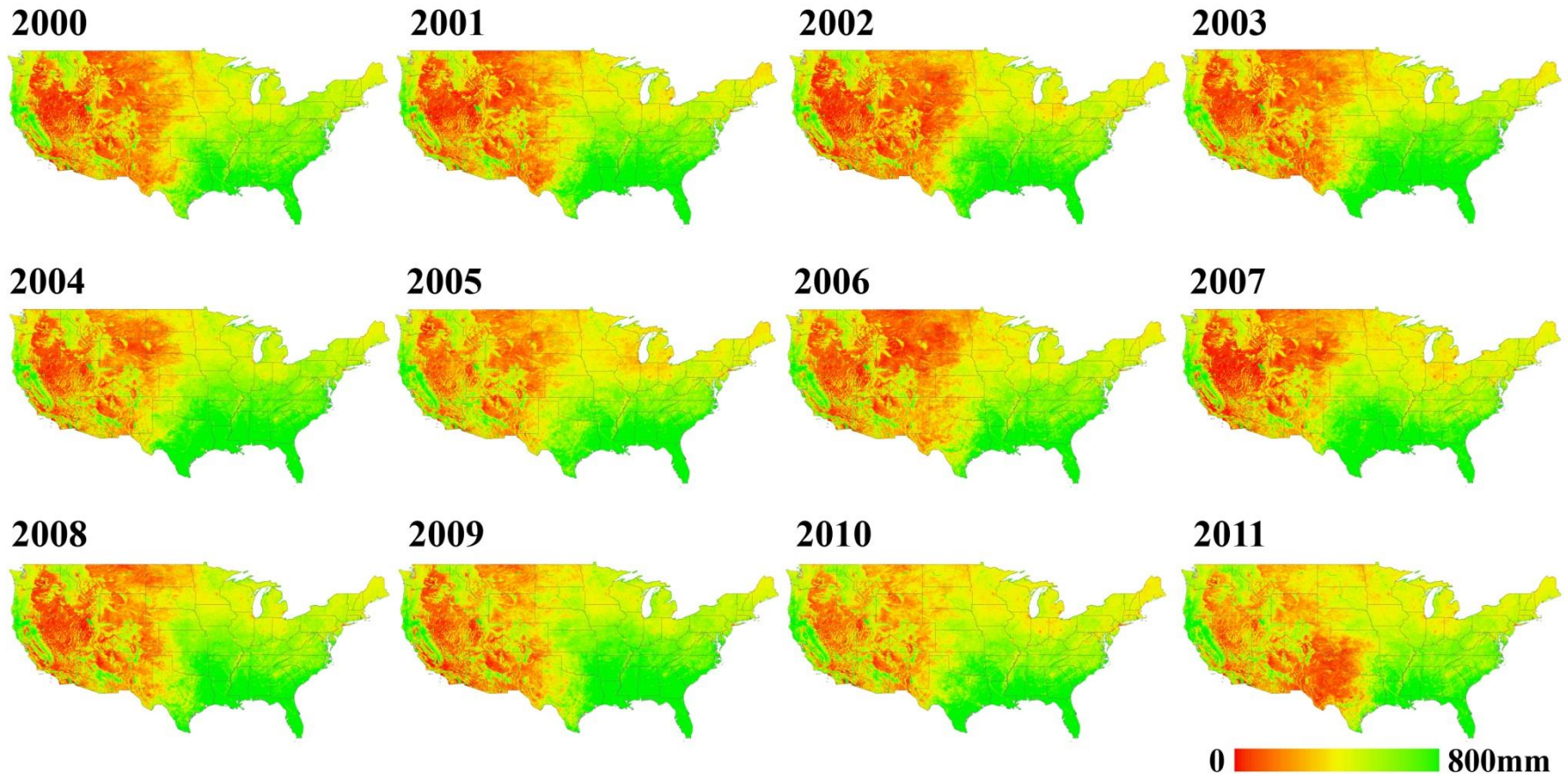


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SSEBop
MODIS ETa
validated
against
42 Ameriflux
Towers
(2001-2007)
by
cover type



SSEBop Annual ETa Totals from MODIS



Landsat Results for Geographic Focus Area Basins:

Colorado (2010, 2013)

ACF (2010)

Delaware (2005, 2010)

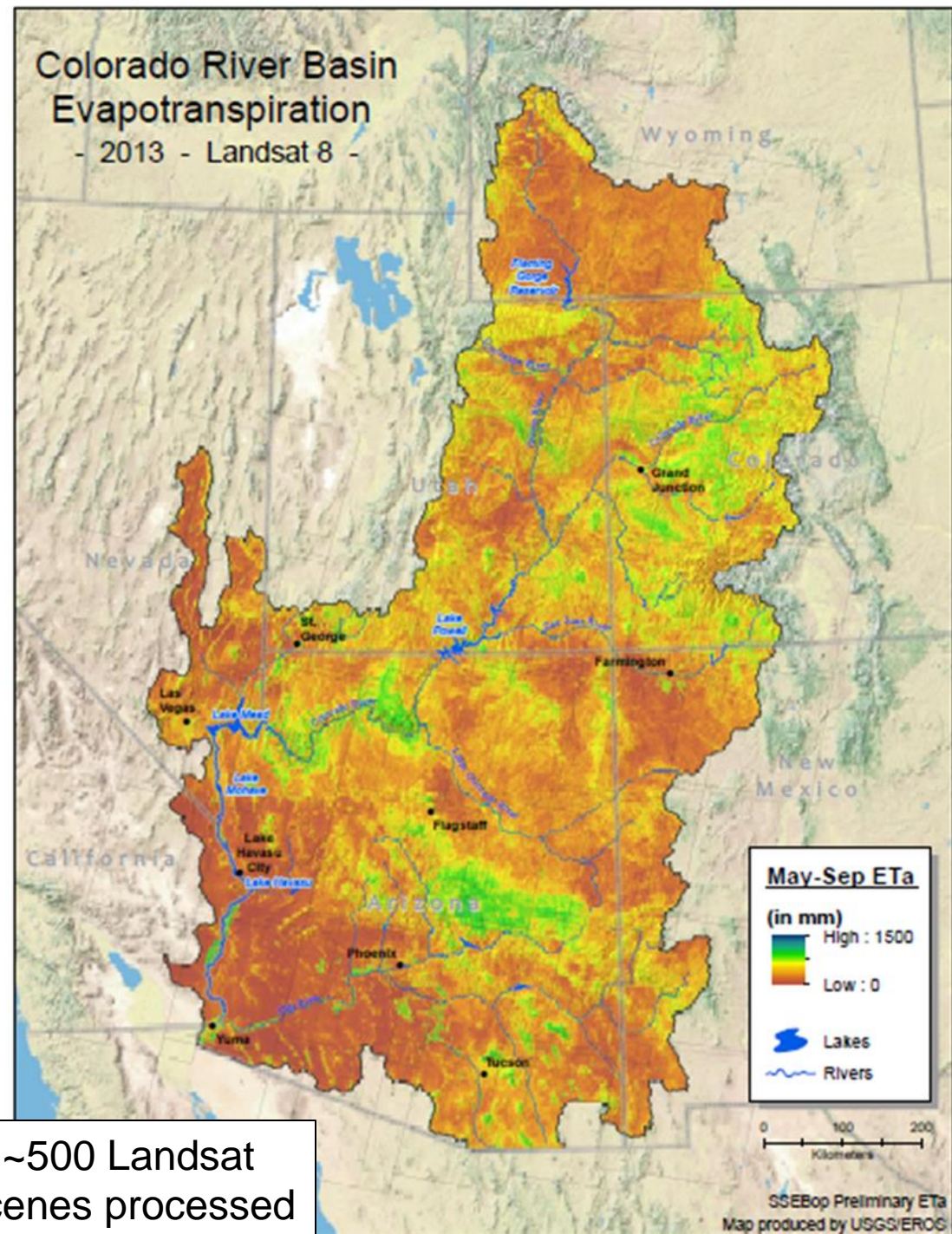
new

Rio Grande

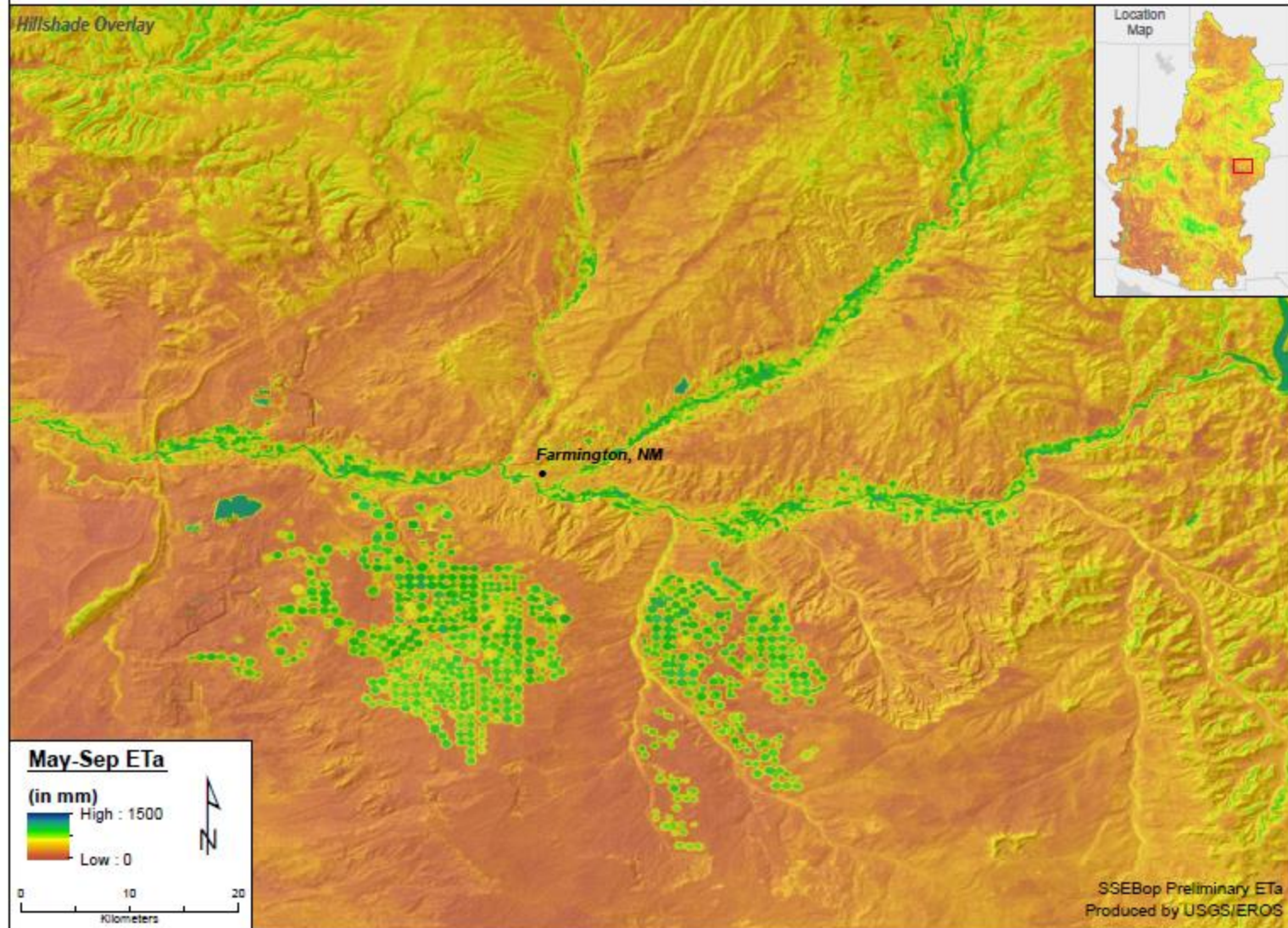
Red River



~500 Landsat
scenes processed

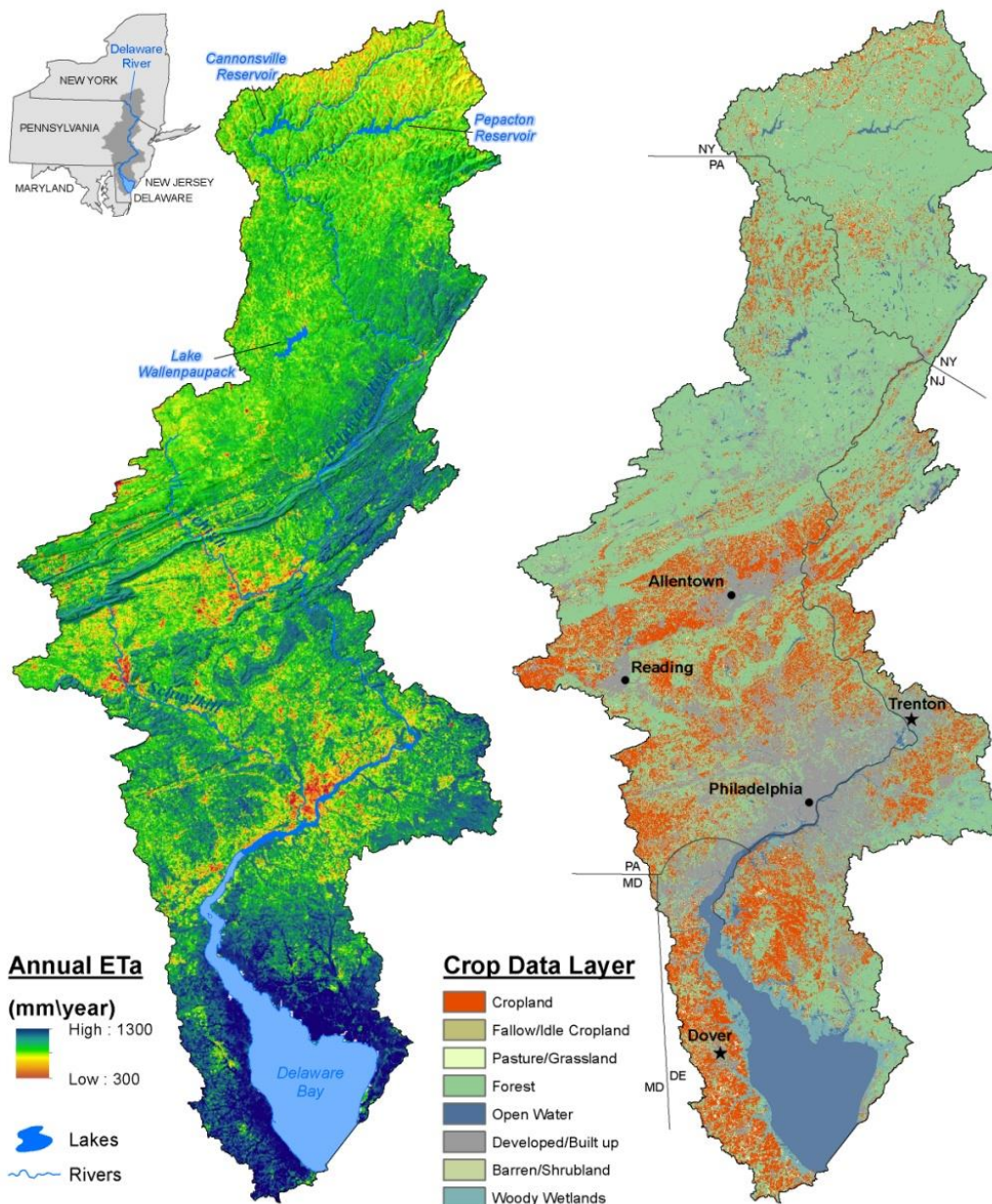


Colorado River Basin Evapotranspiration - 2013 - Landsat 8

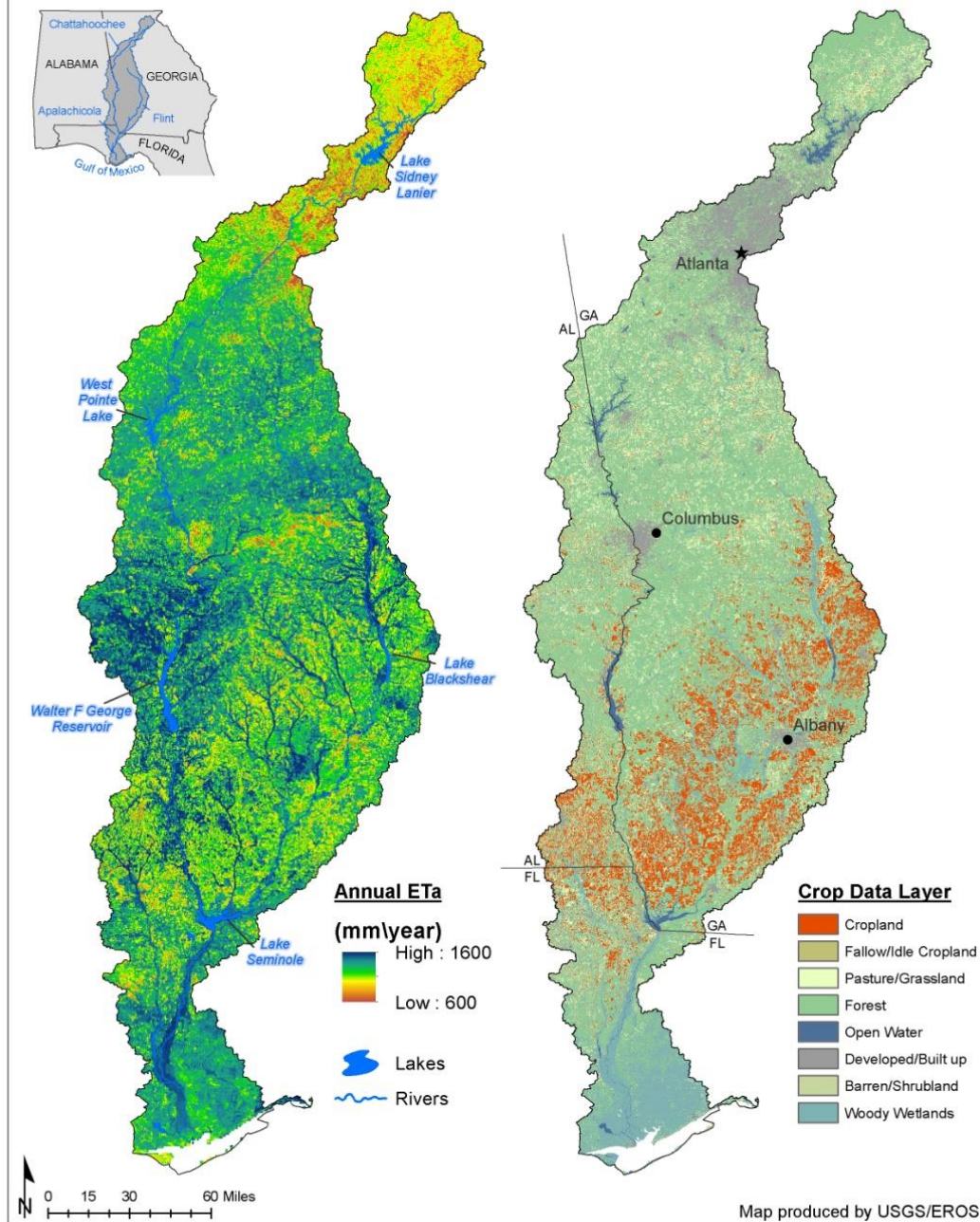


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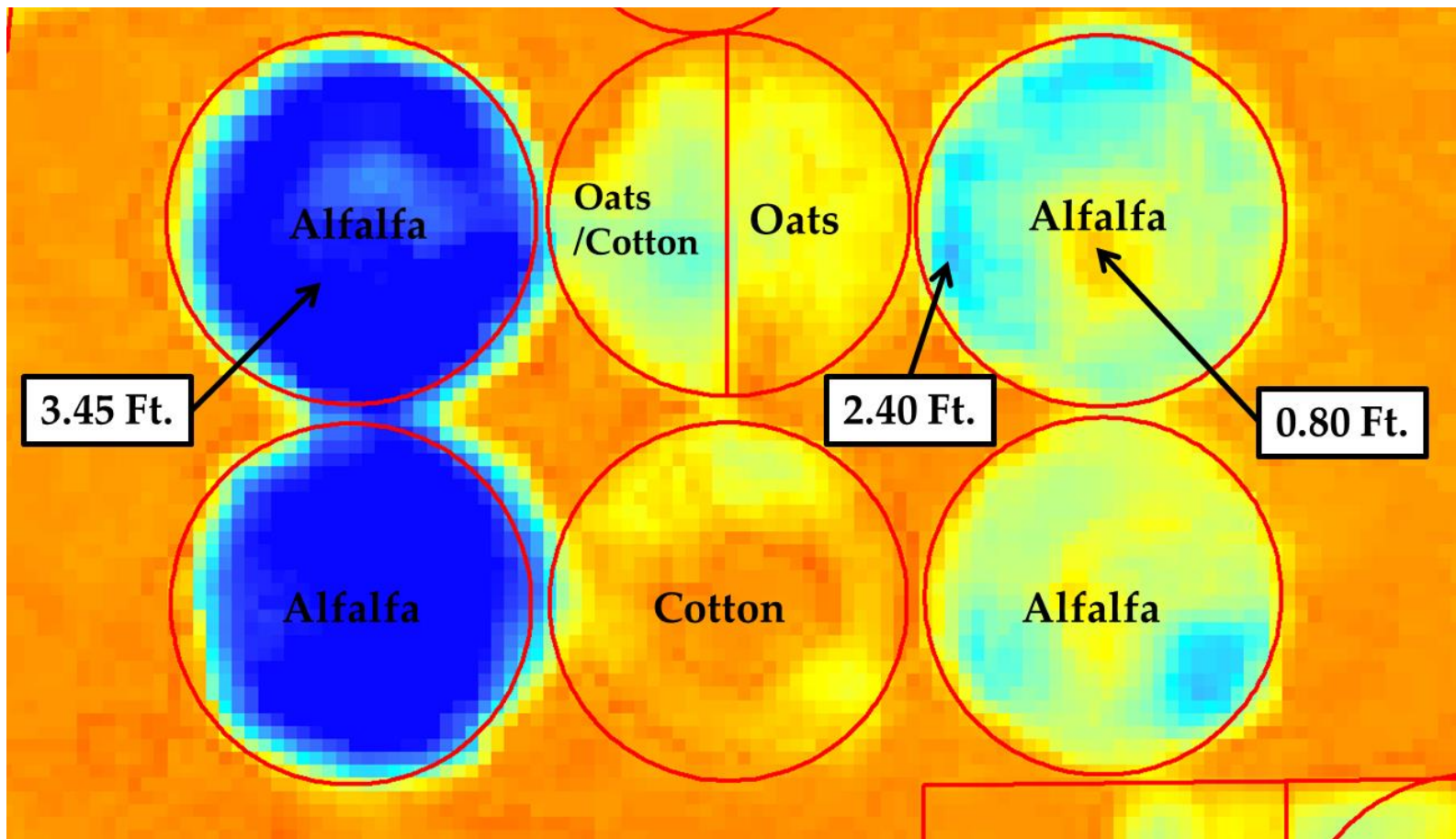
DRB 2010 Annual ETa and Crop Data Layer



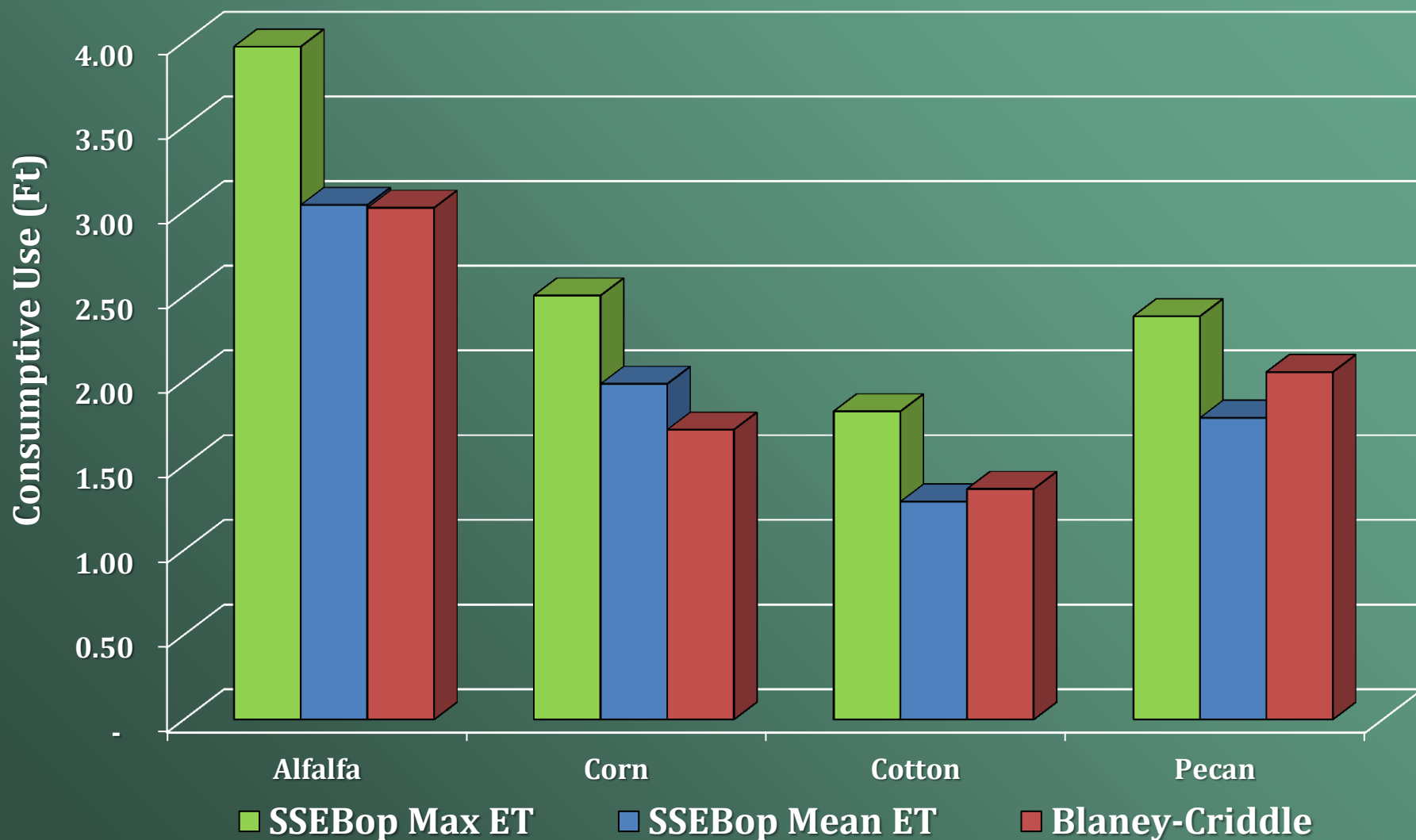
ACF 2010 Annual ETa and Crop Data Layer



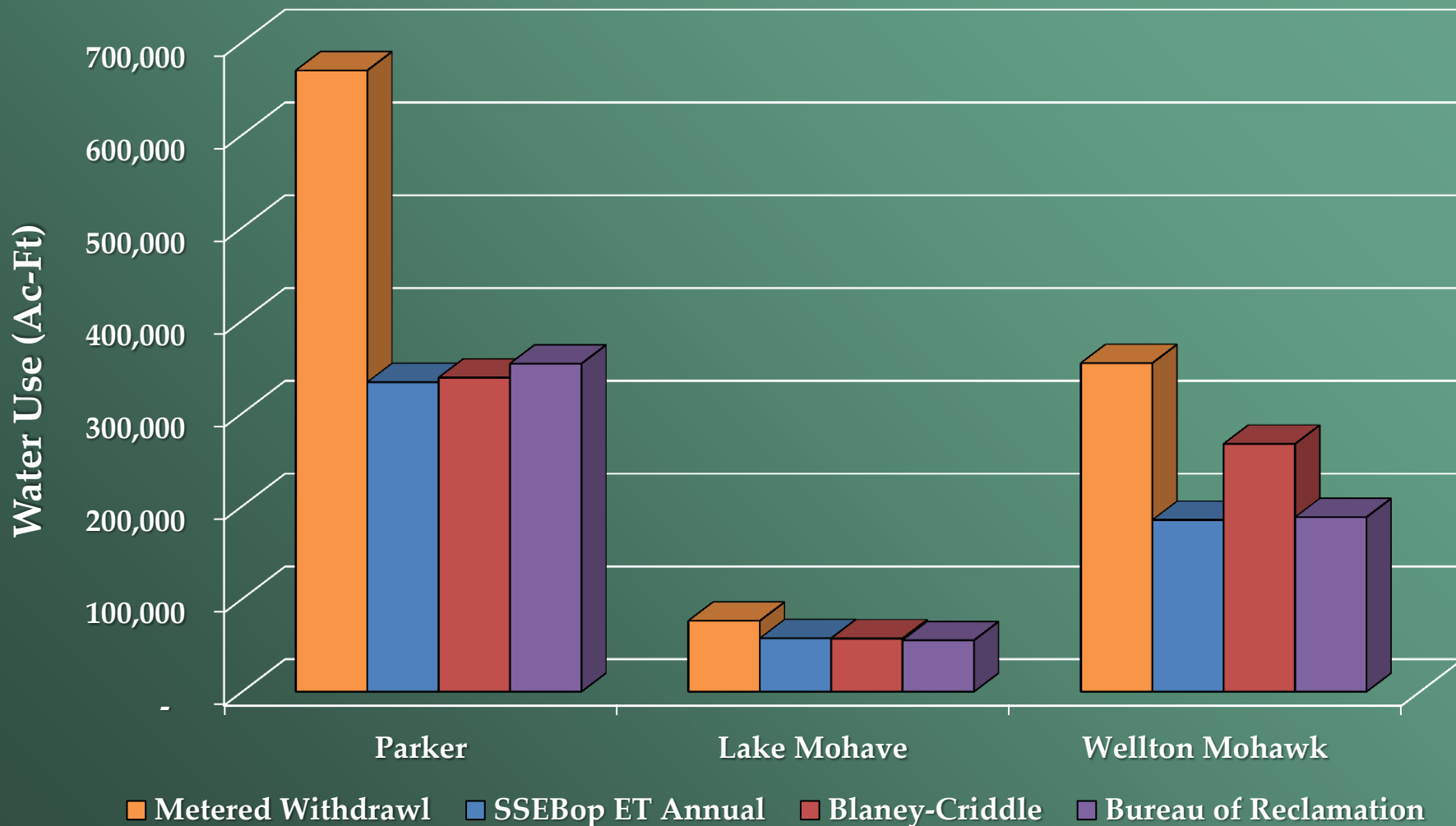
Comparisons – USGS Arizona WSC



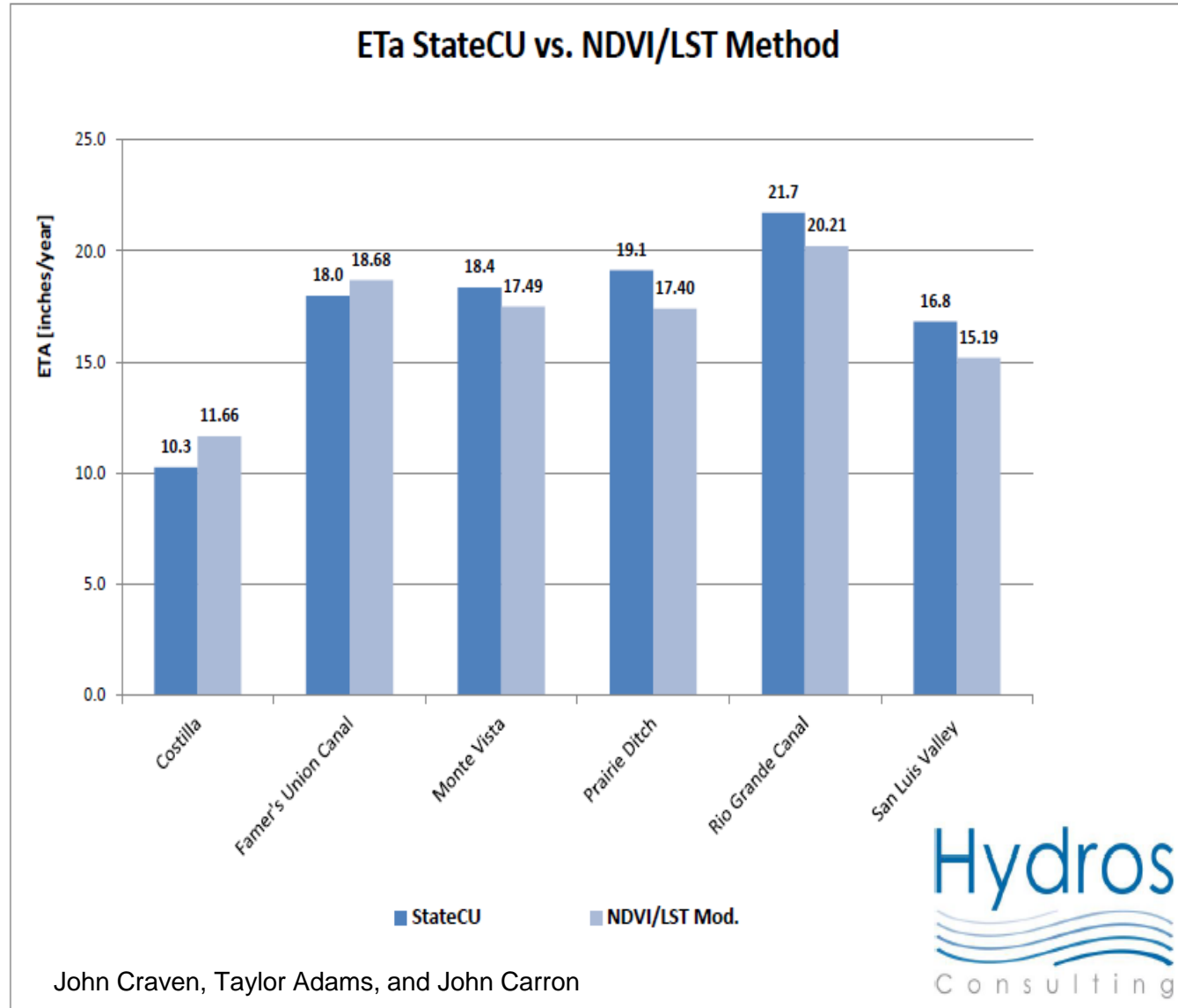
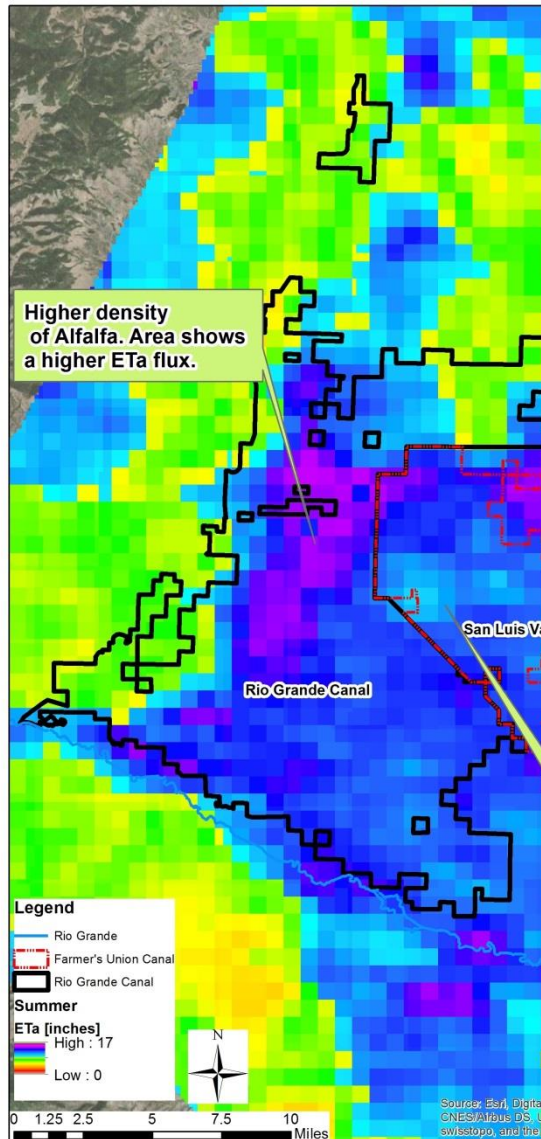
Douglas Basin Consumptive Use by Crop, 2010



Consumptive Use and Withdrawals for Selected Areas, 2010



Comparisons – San Luis Valley, CO



Comparisons – Utah State University

- Begun four years ago**
- Motivation – to facilitate NWC use of Landsat ETa estimates produced by non-USGS organizations**
- National Landsat scale ETa production beyond USGS computational capacity**
- Compare options for models & inputs to develop guidelines and specifications**



Comparisons – Utah State University

Palo Verde Irrigation District – 2008 Annual Actual ET

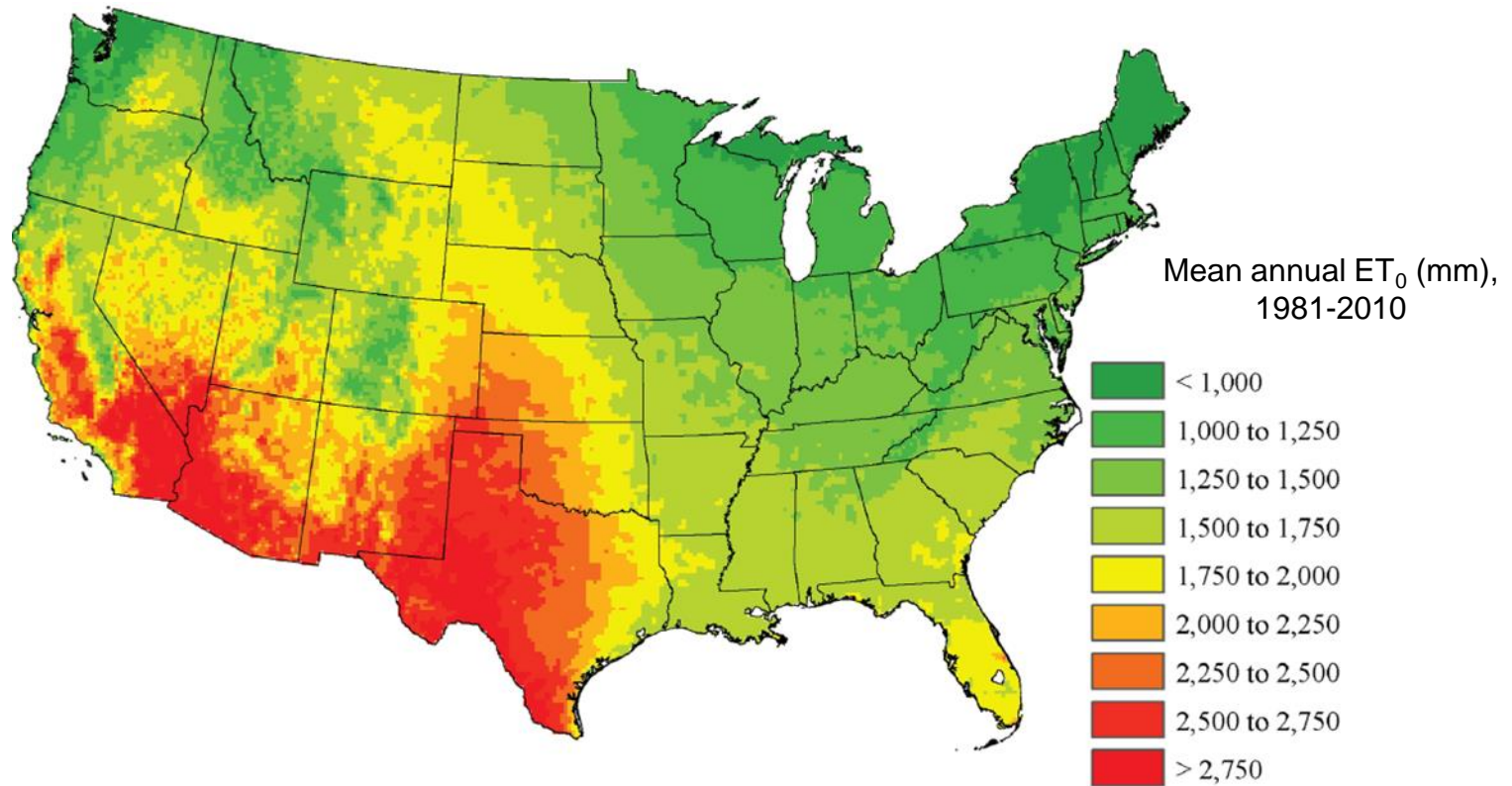
	Water Balance*	METRIC	ReSET	DisALEXI	SSEBop
Actual Evapotranspiration (ETa) (mm)	1128 USBR 1267 USU	1312	1223	1160	1092

(*USBR includes an estimate of unmeasured return flows, while USU does not)

Differences between WB and RS estimates similar (5-10%)
and within the uncertainty of the WB “truth”



Investing in Improvements



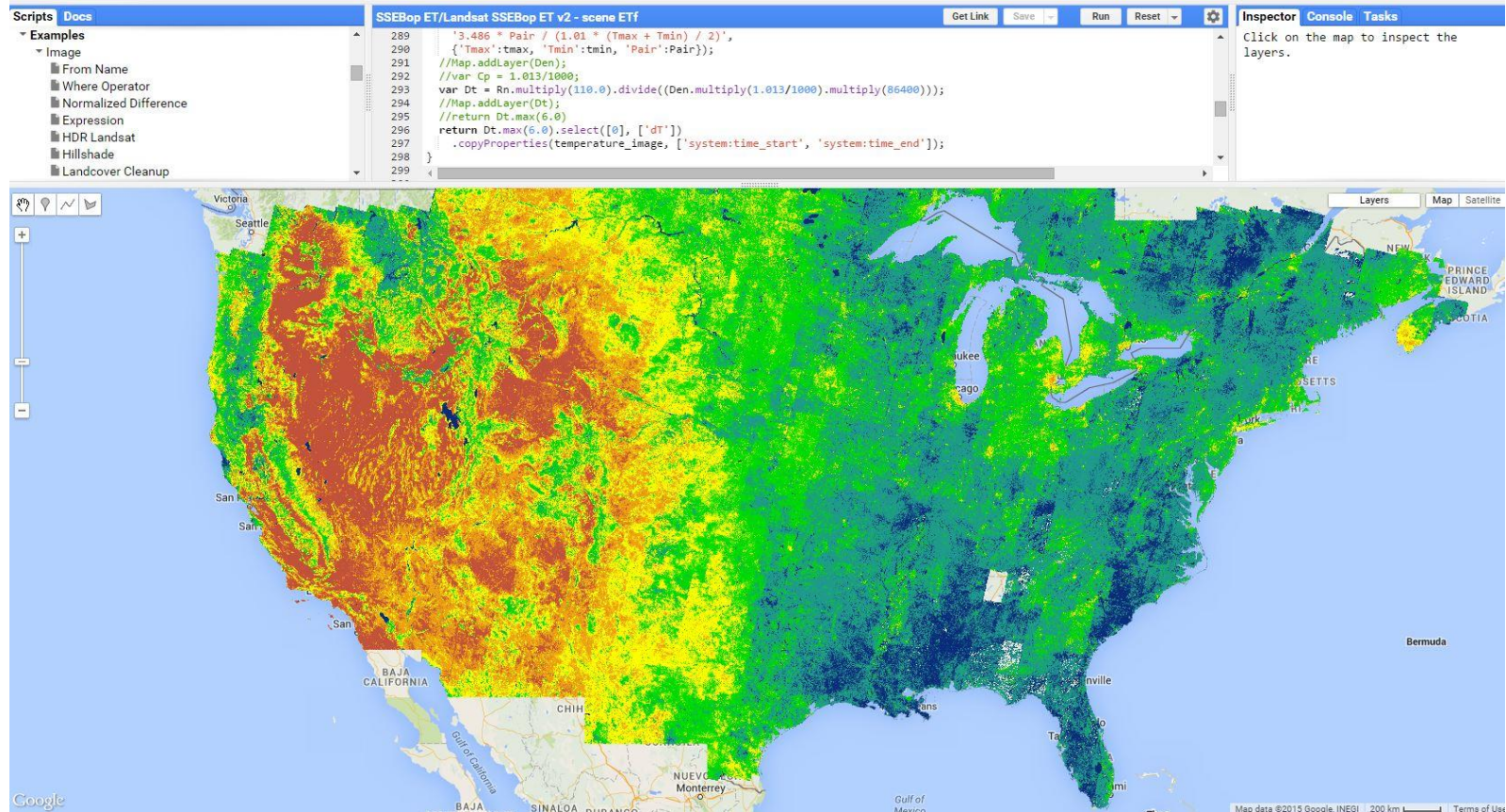
Mike Hobbins, NOAA/CIRES, Gridded Reference ET time series, 1981-2010

ASCE Standardized Reference ET equation forced by NLDAS-2



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Investing in Improvements



Landsat SSEBop in Google Earth Engine – Mac Friedrichs, USGS/EROS



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Lessons Learned

- **All models reviewed compare favorably with available “truth”**
 - **Spatial and temporal patterns stem principally from the LST, NDVI data common to all models**
 - **Differences consist mainly of systematic offsets that can be addressed with local calibration**
- **Inter-comparisons are interesting but inconclusive**
 - **Uncertainty of “truth” data is significant**
 - **“Truth” data are scarce and circulate freely**
 - **“Blind tests” are nigh impossible**

Lessons Learned

- **NWC is best served by nationally consistent methods for estimating water balance components**
- **Piecemeal compilation adds uncertainty to national and regional scale analyses of water availability and water use**
- **Cloud computing has significantly reduced the computational challenges of 4 years ago**
- **Nationally consistent, full landscape Landsat-scale ET estimates are now within reach**

Going Forward

- **Complete cloud computing implementation of SSEBop and benchmark against original code**
- **Apply cloud computing each year to produce Landsat-scale monthly and annual ETa maps**
- **Work retrospectively through the Landsat archive to produce a 30-year + time-series of ETa in the public domain**
- **Analyze ETa climatology to reveal status, trends, and “hot spots” of change**